

IN THE SPECIFICATION:

Please amend paragraph [0003] as follows:

[0003] State of the Art: In the field of semiconductor device manufacture, testing and packaging of various types of semiconductor dice are conducted in a similar manner. Thus, conventional dynamic random access memory dice (~~DRAM's~~), (DRAMs), static random access memory dice (~~SRAM's~~), (SRAMs), programmable memory dice (~~PROM's~~, ~~EPROM's~~, ~~EEPROM's~~), (PROMs, EPROMs, EEPROMs, flash memories), logic dice, and microprocessor dice are fabricated, tested and packaged in a generally similar manner.

Please amend paragraph [0004] as follows:

[0004] Following fabrication of a plurality of dice on a wafer or other bulk substrate of semiconductor material, ~~a cursory~~ preliminary test for functionality is conducted on each die, such as by probe testing. The dice are then singulated, and those passing the functionality test are picked from the wafer, typically for packaging, such as by transfer molding, and subsequent incorporation into a higher-level assembly. Typically, each die is formed with one or more rows of bond pads on the active surface. The bond pad row or rows may be formed along a central axis of the die or along one or more peripheral portions thereof. Transfer molded packages may comprise bond wires which electrically couple bond pads on the die to leads of a lead frame, the outer ends of the leads extending beyond the protective encapsulant, which is typically ~~a silicone-filled~~, silicone-filled, thermoplastic polymer. The lead frame leads are used to achieve mechanical and electric connection of the die to a carrier substrate such as a printed circuit board (PCB), for example.

Please amend paragraph [0007] as follows:

[0007] A board-on-chip (BOC) semiconductor package has also been developed, in which an interposer substrate such as a relatively small, slightly larger than die-size interposer substrate is formed with a centrally placed, elongate through-slot sized and configured for alignment with a row or rows of bond pads on the die. The through-slot is also known as an

“interconnect slot” or “wire bond slot.” The die is adhesively joined by its active surface to one side of the interposer substrate such that the bond pads are accessible through the interconnect slot. The bond pads are connected to conductive traces on the opposite side of the interposer substrate, by bond wires, for example, which pass through the interconnect slot. The interconnect slot is then filled with a ~~filled~~ silicone-filled, thermoplastic polymer encapsulant to encase and seal the bond wires and surrounding, exposed portion of the die’s active surface. Conventionally, a transfer molding process is used to form this wire bond mold cap while simultaneously encapsulating the ~~backside~~ back side and sides of the die on the opposite side of the interposer substrate. A ball grid array (BGA) or other type of array of discrete conductive elements electrically connected to the conductive traces and projecting from the side of the interposer substrate with the wire bond cap may be used to mechanically and electrically connect the package to a carrier substrate or other higher-level packaging. Various examples of this type of package construction are shown in U.S. Patent Nos. 5,723,907 ~~and to Akram and~~ 5,739,585 to Akram et al., and 5,818,698 to Corisis, all of which patents are assigned to the assignee of the present application and the disclosure of each of which is incorporated by reference herein. The resulting package has a much reduced size, which may be termed “chip scale” or “near chip scale,” and is generally capable of establishing robust, ~~high-quality~~ high-quality mechanical and electrical connections using conventional bonding techniques.

Please amend paragraph [0009] as follows:

[0009] Despite the obvious advantages for this BOC-type of semiconductor package, a problem has been repeatedly noted relative to the integrity of the wire bond mold cap. Stress cracking of the wire bond mold cap has been found to occur at an unacceptably high frequency in certain package ~~configurations, which~~ configurations. The ~~undesirable~~ stress cracking has been found to be attributable to tensile stresses induced in the interconnect or wire bond slot region during temperature cycling, thermal shock, curing in the mold during the encapsulation process, etc., as the package interposer substrate is cycled between compressive and tensile stress states. This cycling is due in large part to the disparity ~~in~~ of encapsulant volume on opposing sides of

the interposer substrate and the associated stress cracking to reduced rigidity against bending of the interposer substrate due to the presence of the interconnect or wire bond slot extending along a majority of the centerline or longitudinal axis of the interposer substrate.

Please amend paragraph [0010] as follows:

[0010] The aforementioned stress cracking in conventional BOC-type packages has been found to be largely concentrated at the interface between the interconnect slot edge and the mold cap itself. It has been recognized by those skilled in the art that the ~~magnitude and~~ frequency of occurrence and magnitude of this problem is greater where the length of the elongated, central interconnect slot is a major portion of the corresponding substrate length. In BOC-type packages having an interposer substrate with an interconnect slot, the interconnect slot length is typically about 70 to 80% of the corresponding substrate length. It has been estimated that an unacceptably high failure rate generally occurs where the slot length is about 67% or more of the substrate length (for a bismaleimide triazine (BT) resin substrate). Thus, the problem may be very pervasive, as such relative slot lengths are quite common and necessary to accommodate the large number of bond pads required for operation of state of the art dice. Where the interposer substrate comprises another material, such as a ceramic for example, the critical ratio of slot length to substrate length may be somewhat different.

Please amend paragraph [0018] as follows:

[0018] FIG. 3 is a schematic ~~graphical~~-view of tensile bending stresses exerted on a BOC semiconductor package such as the prior art semiconductor package of FIG. 1 as a function of lateral distance from the centerline thereof;

Please amend paragraph [0021] as follows:

[0021] FIG. 5A is a top-~~elevation~~-elevation view of a variation of the reinforced interposer substrate of FIG. 5;

Please amend paragraph [0027] as follows:

[0027] In use and operation, and referring to FIG. 1, an exemplary BOC semiconductor package 10 of the prior art is depicted. The semiconductor chip or die 12 has an active surface 14 and a back surface 16. The die 12 is shown with a plurality of bond pads 34 disposed on the active surface 14, in one or more mutually parallel, generally linear rows 36 (see FIG. 4) along a centerline bisecting the active surface 14. Generally, the bond pads 34 have a uniform interpad spacing or pitch 8 (see FIG. 4).

Please amend paragraph [0029] as follows:

[0029] In FIG. 1, die 12 is shown as having its active surface 14 mounted on a die attachment area 18 on the surface 22 of interposer substrate 20 by adhesive material 32. The adhesive material 32 may comprise one of many suitable adhesives such as thermoplastic adhesive, a thermoset adhesive or one or more tape or film segments such as a polyimide (e.g., ~~KAPTON~~ Kapton tape®) having a pressure-sensitive adhesive on both sides thereof.

Please amend paragraph [0031] as follows:

[0031] FIG. 1 also illustrates bending stresses 72 which occur when the package 10 is subjected to temperature cycling and thermal shock. The interposer substrate 20 is thus cycled back and forth between compressive and tensile stress conditions. When in a tensile state, the bending stresses 72 act on the wire bond mold cap 56 and the edges 46 of the interconnect slot 40, tending to separate them. Cracks 58 propagate at the interface 74 between the mold cap 56 and edges 46, or within the mold cap 56 itself, to relieve the applied tensile stress. Breakage of bond wires 38 lying in the path of a crack 58 may also occur. As depicted in the generalized graph of FIG. 3, the stress values 61 (whether tensile or compressive) increase as shown at 62 toward the center of interposer substrate 20 and attain peak values 64 generally along the centerline 42 of the interposer substrate 20. Conversely, stress levels decrease with distance 66 from the centerline 42 of interposer substrate 20. Of course, it is the occurrence of

peak values ~~64, for stress~~ 64 for stress, which causes the aforementioned damage in the interconnect slot 40 region of interposer substrate 20.

Please amend paragraph [0032] as follows:

[0032] FIG. 2 depicts the exemplary interposer substrate 20 of FIG. 1. Interposer substrate 20 is shown in this embodiment as a planar member with a surface 22 and an opposed surface 24. The interposer substrate 20 has a length 52. A die 12 (not shown in FIG. 2) with a central row 36 of bond pads 34 will be attached to die attachment area 18 on the surface 22 such that the bond pads 34 will be exposed through the interconnect slot 40. Conductive traces 30 (not shown in FIG. 2) are formed on the surface 24, as already discussed. As shown, the interconnect slot 40 has a length 48 which, in many instances, is about 70-80% of the interposer substrate 20 length 52 so as to extend a length at least slightly greater than the row or rows 36 of centrally placed bond pads 34 of the die 12 with which interposer substrate 20 is assembled. The slot width 50 is typically made as narrow as possible because of the required space for conductive traces 30 on the outer surface 24 of interposer substrate 20, but is required to be of sufficient width to accommodate a wire bond capillary used to place bond wires 38 and therefore, form bonds with bond pads 34 and the ends of conductive traces 30 adjacent interconnect slot 40. Also shown are vertical axis 28 oriented perpendicular to the plane of interposer substrate 20 through the interconnect slot 40 and longitudinal axis or centerline 42 extending through the interconnect slot 40 in the plane of interposer substrate 20. The interconnect slot ends 44 are typically rounded or filleted, a natural consequence of slot formation in the interposer substrate 20 by milling. ~~Slot- Rounded slot ends 44 rounded as shown as illustrated in FIG. 2,~~ therefore, have higher a greater strength than, e.g., squared ends, the corners of which are subject to crack initiation and propagation.

Please amend paragraph [0033] as follows:

[0033] In the present invention, one or more crosspieces or bridges 70 (FIG. 4) are formed between the slot ends 44 of the elongate interconnect slot 40. These crosspieces or

bridges provide a multisegmented interconnect slot 40 and reinforce the interposer substrate 20 between the opposing edges 46 of the interconnect slot 40 at intermediate locations along the interconnect slot 40 against bending attributable to stresses applied thereto. Turning now to FIG. 4, one exemplary embodiment of the interposer substrate 20 of the invention is shown, together with a die 12 with a single central row 36 of bond pads 34. A crosspiece or bridge 70 comprises a filleted portion of the interposer substrate 20 which is left uncut during manufacture, i.e., two longitudinally adjacent interconnect slots or slot segments 40A, 40B are formed in interposer substrate 20 instead of a single interconnect slot 40 (as depicted in FIGS. 1 and 2), leaving crosspiece or bridge 70 in place. The interconnect slot segments 40A, 40B of the present invention are shown with a combined length ~~(48A + 48B)~~ of 48A plus 48B, which is slightly less than the length 48 of a single prior art interconnect slot 40 for a similarly sized interposer substrate 20. However, the longitudinal distal end-to-distal end length of the two interconnect slot segments 40A, 40B may be equivalent to, or even longer than, that of a single prior art interconnect slot 40. The width 76 of the crosspiece or bridge 70 in the direction of centerline 42 is small, generally about 0.5 mm or more for a BT resin interposer substrate 20 given manufacturing tolerances, ~~but~~ yet sufficient to extend between longitudinally adjacent bond pads 34. It may be desirable to space bond pads 34 into two or more longitudinally adjacent groups with increased interpad spacing or pitch 8 between groups of the plurality of bond pads 34, as depicted in FIG. 9, to enable the use of larger-width crosspieces or bridges 70, ~~as depicted in FIG. 9~~. If necessary, more than one crosspiece or bridge 70 may be used, generally evenly spaced along the interconnect slot 40 (see slot segments 40A, 40B and 40C in FIG. 9A), to divide the interconnect slot 40 into three or even more segments to provide a required resistance to bending. Generally, however, for ~~bond pad row lengths 84~~ overall length 84 of the row 36 of bond pads 34 for dice 12 of about 3 to 15 mm in length, a single, substantially centrally placed crosspiece or bridge 70 is sufficient to avoid stress cracking or delamination of the wire bond mold cap 56. For longer dice 12, two or more longitudinally spaced crosspieces or bridges 70 may be desirable to thereby avoid stress cracking or delamination of the wire bond mold cap 56.

Please amend paragraph [0034] as follows:

[0034] Referring now to FIG. 8, a cross-sectional end view of a BOC semiconductor package 100 according to the present invention is illustrated. Elements and features of semiconductor package 100 are substantially the same as those of BOC semiconductor package 10, ~~but for the presence~~ however, a notable addition to semiconductor package 100 is the transverse extension of crosspiece or bridge 70 extending transversely across interconnect slot 40, thereby dividing it interconnect slot 40 into slot segments 40A and 40B (see FIG. 4).

Please amend paragraph [0035] as follows:

[0035] FIG. 5 illustrates another embodiment of a crosspiece or bridge 70. In this version, the crosspiece or bridge 70 comprises a narrow segment of material which is adhered by its underside 86 to surface 24 of interposer substrate 20 with a high-strength adhesive. This crosspiece or bridge 70 may be formed of a high-strength material with a coefficient of thermal expansion (CTE) approximating the CTE of the interposer substrate 20. For example, a reinforced polymer (such as a glass-reinforced polymer) may be used to form a thin-tape crosspiece or bridge 70 having a minimum width 76 of about 0.5 mm. Other reinforced materials such as a polyimide tape, a ceramic element or a silicon-type element may be used.

Please amend paragraph [0036] as follows:

[0036] It is also contemplated, as illustrated in FIG. 5A, that a laterally elongated “I”-shaped segment 70A bearing adhesive material 32 on both sides thereof and used for mounting a die 12 to interposer substrate 20 may be formed such as by die-cutting from a larger sheet of reinforced polymer, for example, and placed on surface 22 of interposer substrate 20 with the head 70H and foot 70F of the “I”-shaped segment 70A lying on opposing sides of an interconnect slot 40 and the body 70B of the “I”-shaped segment 70A forming the reinforcing crosspiece or bridge 70 thereacross. Of course, segment 70A may also be formed with two or more crosspieces to extend at intervals across interconnect slot 40, or two or more “I”-shaped

segments 70A employed. Segment 70A may comprise, for example, a tape segment or a relatively stiff plastic segment.

Please amend paragraph [0037] as follows:

[0037] FIG. 6 depicts a further embodiment of a crosspiece or bridge 70 which comprises a narrow plug or bar of material joined to each of the opposed slot edges 46A and 46B, preferably by a high-strength adhesive. This narrow plug or bar of material is preferably a dielectric material with sufficient strength to accommodate the compressive and tensile stresses applied along the opposed slot edges 46A and 46B, respectively. The various types of materials which may be used to form the plug or bar include, for example, glass, rigid plastic and ceramic.

Please amend paragraph [0039] as follows:

[0039] As noted above, for dice 12 which may normally have an interpad spacing or pitch 8 (see FIG. 4) less than about 0.5 mm, the die design to accommodate any of the foregoing embodiments of the present invention may require a slightly larger bond pad spacing at one or several locations along the row 36 of bond pads 34. Thus, for example, a die 12 may be formed with a bond pad spacing of 0.4 mm along 95% of the row 36 of bond pads 34, while the spacing between two adjacent centrally located bond pads 34 is increased to 0.6 mm. Thus, a crosspiece or bridge 70 may be accommodated without significantly changing the overall length 84 of the row 36 of bond pads 34. Such an arrangement of bond pads 34 on a die 12 in the form of three groups of bond pads 34, each group of bond pads 34 comprising two parallel rows flanking the centerline of the die 12, is illustrated in FIG. 9. However, in the embodiments of FIGS. 5, 5A, 6 and 7, it should be noted that use of a crosspiece or bridge 70 of a higher strength against bending than the material of interposer substrate 20 may enable the use of a thinner crosspiece or bridge 70 which may accommodate existing bond pad spacing or pitch 8. Similarly, if an appropriate material is selected for interposer substrate 20 and ~~tight~~ stringent manufacturing



tolerances may be held, a thin-~~but~~ yet effective crosspiece or bridge 70 may provide adequate resistance to bending stresses while still accommodating existing bond pad spacing or pitch 8.

Please amend paragraph [0041] as follows:

[0041] In the discussion thus far, it is noted that the dice 12 are disposed on a planar surface 22 of the interposer substrate 20. However, the present invention is applicable to semiconductor packages in which the interposer substrate 20 or a base ~~including~~ comprising the interposer substrate 20 has a die-receiving cavity and/or a conductor-carrying cavity on a surface 22 or an opposed surface 24 thereof.

Please amend paragraph [0042] as follows:

[0042] It will be recognized from the above description that the segmentation for reinforcement of interconnect slots 40 in BOC semiconductor packages through the use of crosspieces or bridges 70 enhances the functionality and reliability of such semiconductor packages.